Energy Audit of Asejire Community for a Small Hydropower Scheme

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Abstract— Energy is an important infrastructure for national development. In Nigeria the erratic power supply experienced, and especially in rural areas is an important concern. Energy audit is the assessment of the energy need and efficiency of a building. Hence, energy audit of Asejire community was conducted for developing a small hydropower scheme (SHP) for power generation. The household appliances used were determined, the appliances consuming the most energy in a rural setting were identified, buildings with high energy consumption were identified; and their energy need was evaluated. 1817 kW h was the daily energy consumption of the Asejire community with houses being the most energy consuming buildings by the community, while Nigerian Bottling Company (NBC) an industry in Asejire town had an average daily energy consumption of 29700 kW h. This gave a daily total energy consumption of 31517 kW h with a rated power of 1.389 MW. The energy need of the Asejire Community can be solved with the incorporation of a Small Hydropower Scheme (SHP) by utilizing the Asejire dam and thereby matching their energy demand with the energy supply from the Small Hydropower Scheme (SHP).

Keywords— Asejire community, energy audit, electricity, rated power and small hydropower scheme

1 INTRODUCTION

Existence of life is dependent on energy. Humans need energy for comfort, cooking, heating, transportation, safety etc. A simple example are plants which use the process of photosynthesis for the generation of carbohydrate in the presence of light energy. Our society today can be deemed as a high energy consumption society with an increasing population. Therefore, energy must be readily available, reliable and affordable. Economic development is a function of volume of energy consumed. Energy has a major impact on every aspect of our socio-economic life. It plays a vital role in the economic, social and political development of our nation. Inadequate supply of energy restricts socio-economic activities, limits economic growth and adversely affects the quality of life (Energy Commision of Nigeria, 2003).

Although, various forms of energy exist. They can be classified primarily into conventional and unconventional forms of energy. The earlier being the most consumed form of energy –fossil fuels and the latter mostly renewable forms of energy. The primary source of energy are usually converted into secondary form of energy — electricity. Electricity which is a secondary form of energy has tremendous advantage due to its convenience and flexibility. No other kind of energy afford such an instant and effortless access.

The energy supply in Nigeria is inadequate and the available infrastructure for providing and extending these required energy especially to rural areas have continued to diminish and have become grossly inadequate (Otun, Onemano, & Alayande, 2012). Asejire community was chosen as the case study because she is a rural community experiencing inadequate supply of energy, and also home to the Asejire dam. Asejire community is located in Oyo State, Nigeria, and there are over a thousand people living in the community.

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The community is well known for the Asejire dam located in the Asejire town which was built in 1972, stores approximately 7240 million gallons of water, and rises above 80 feet of the Osun river (Gilbert Associates, Inc., 1963) and the dam is used for water supply to Oyo State (OWAS, 2008), Nigerian Breweries and the Nigerian Bottling Company plant also located in the Asejire town. The town is a rural community and it is currently experiencing growth.

The objective of this study is to determine the energy need of Asejire community with the potential of providing available information on their energy demand. And a proposed solution to their current energy problem by developing a small hydropower scheme for power generation to match their current energy demand.

2 METHODOLOGY

The present electrical energy demand of the neighbouring community was evaluated by carrying out an energy audit to determine the averagely used appliances and their power rating. An energy audit questionnaire was used to carry out the energy audit. A rural community is one with a population of less than 20,000 and an assumed average household of 10 (Adejumobi, Adebisi, & Oyejide, 2013). Since the neighbouring community is a rural community with the inclusion of a Nigerian Bottling Company (NBC) plant. Therefore, NBC plant energy consumption was obtained from the NBC facility manager. Asejire Town is shown in the map in Figure 1.

A team of 10 people divided into two subgroups were given half of the Asejire community to audit — west and east side of the town. The audit was carried out for 5 days. Each group went to the buildings in the Asejire community and asked for an elderly respondent in the building and explained the purpose of the audit and carried out the survey with the necessary questions. The data from the survey was analysed and compiled on a spread sheet using a Microsoft Office suite software— Excel. Then, a statistical representation using bar chart of the analysed data was prepared.

The energy consumption was evaluated using equation (1).

$$E = p_r \cdot t \cdot n \quad (1)$$

Where, E is the energy consumed in kW h.
P_r is power rating of appliance in kW.
t is the average time the appliance is operated in hr.
n is the number of the same appliance in operation.

3 Results and Discussions

3.1 Energy Audit

The stated results below reflect the data obtained from the survey of the Asejire community.

- Population: 1000 – 2000.
- Buildings: 80 – 140.
- Electrical connection: Available in some part of the community.
- Alternate source of electricity: Petrol generator.

Note: All energy values for the Asejire community are calculated on a daily basis and a 12hr average operation time for each appliance is used.

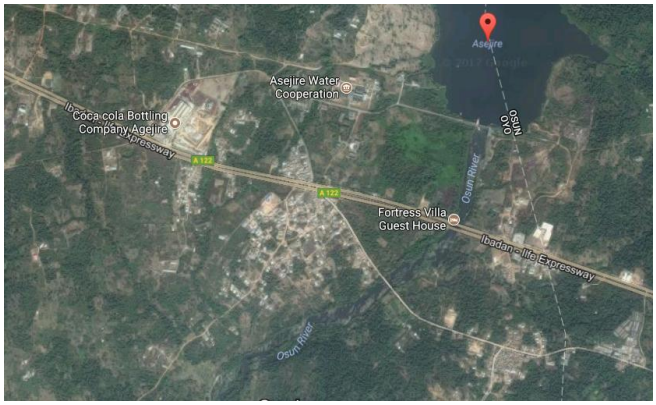

Fig 1: Map of Asejire Town (Source: Google Maps, 2017)

3.2 Results of Energy Consumption

Community Energy consumption= 1652 kW h
Miscellaneous: 10% of Community Energy consumption= 165.2 kW h
Total community energy consumption= 1817.2 kW h
NBC plant Energy consumption= 27000 kW h
Miscellaneous: 10% of NBC plant energy consumption= 2700 kW h
Total NBC plant energy consumption= 29700 kW h
Total Energy Consumption (TEC): Total community energy consumption + Total NBC plant energy consumption
Total Energy Consumption= 1817.2+ 29700= 31517.2 kW h

3.3 Results of Rated Power

Community rated power= 137.73 kW
Miscellaneous: 10% of community rated power = 13.77 kW
Total community rated power = 151.5 kW
NBC plant rated power= 1125 kW
Miscellaneous: 10% of NBC plant rated power= 112.5 kW
Total NBC plant rated power: 1237.5 kW
Total Rated Power (TRP): Total community rated power + Total NBC plant rated power
Total Rated Power= 151.5 + 1237.5= 1389 kW

A detailed compilation on a spreadsheet is shown in Table 1 and Figs. 2 & 3 show a graphical representation of the energy audit data.
From the data above lighting, heating and cooling appliances consumed the most energy. A typical household has more than four electrical bulbs installed and they are mostly of the incandescent type. While heating and cooling appliances except fans are only used by a few of the households but consumes much energy because of their high rated power. The appliances used are fairly efficient but more energy savings would be achieved by using more efficient appliances such as energy saving bulbs rather than the use of incandescent bulbs for lighting. Among the building in the community, houses consumed the most energy. The school consumed the least energy because it is a public school with few appliances being used. Future expansion indicates that more heating and cooling appliances would be used which would increase the energy demand of the Asejire community. Therefore, allowance would have to be given for future energy demands.

The results showed that the Asejire community daily energy consumption was 1817.2 kW h with a rated power of 151.5 kW. While Nigerian Bottling Company had a daily energy consumption of 29700 kW h and a rated power of 1237 kW h which is about eight times the daily energy need of the Asejire community. The total daily energy need of both the Asejire community and Nigerian Bottling Company plant was 31517 kW h and a total rated power of 1389 kW. The energy demand of the Asejire community alone can be powered by a modular power generating system by taking advantage of the Asejire dam located in the Asejire town by creating a small hydropower scheme.

The theoretical electrical power ranging from 5.13 kW to 5,000 kW is realizable in Nigeria if the identified small hydropower sites are developed and which is enough to cater for average rural community loads (Adejumobi, Adebisi, & Oyejide, 2013). Most industries are self-sufficient in energy supply by having an independent power generating system. But, the Asejire community can experience rapid industrialization with the incorporation of a sustainable and reliable power generating system. The town is known to attract industries because of the availability and access to water as a raw material

Table 1: Spreadsheet of energy audit results

	Light bulb	Fan	Television	Video Player	Fridge	Freezer	Hair dryer	Mobile Charger	Iron	Water Pump	Air conditioner	Lotto machine	Speaker	Amplifier	Washing machine	Electric kettle	Printer	Toaster	Clipper	Computer	Satellite Tv	Radio	Energy consumption	Power rating
House 1	2.88	1.44	2.40	0.96																			7.68	0.64
House 2																							0.00	0.00
House 3	5.76	2.88	1.20	0.48	9.00																		19.32	1.61
House 4								0.48															0.48	0.04
House 5																							0.00	0.00
House 6																							0.00	0.00
House 7								0.48															0.48	0.04
House 8	4.32	2.16	2.40	0.96	9.00																		18.84	1.57
House 9	4.32	2.16	2.40	0.48																			9.36	0.78
House 10	5.76	2.88	3.60	0.96					24.00	9.00													46.20	3.85
House 11	7.20	5.76	3.60	1.92				0.60		9.00	18.00												46.08	3.84
House 12	5.76	2.88	2.40	0.96				0.30														3.60	15.90	1.33
House 13								0.30															0.30	0.03
House 14	5.76	2.88	3.60	0.96				0.30														2.40	15.90	1.33
House 15	5.76	2.88	3.60	1.44				0.48														3.60	17.76	1.48
House 16	5.76	4.32	2.40	0.96				0.30														3.60	17.34	1.45
House 17	4.32	2.16						0.48														3.60	10.56	0.88
House 18	3.60	2.16	1.20	0.48				0.30		9.00												1.20	17.94	1.50
House 19	3.60	2.16	1.20	0.48	9.00			0.30	12.00													1.20	29.94	2.50
House 20	4.32	2.16						0.30														4.80	11.58	0.97
House 21	5.76	4.32	2.40																			3.60	16.08	1.34
House 22	7.20	4.32	2.40	0.96																		6.00	20.88	1.74
House 23	8.64	5.76	4.80	1.92				0.48														3.60	25.20	2.10
House 24	4.32	2.16																				4.80	11.28	0.94
House 25	5.76	5.76	4.80	0.48				0.60															17.40	1.45
House 26	7.20	7.20	7.20		18.00			0.60	24.00	18.00	36.00									3.60			121.80	10.15
House 27	8.64	5.76	4.80	1.44	18.00				24.00	9.00											1.20		72.84	6.07
House 28	3.60	2.16	1.20		9.00				12.00														27.96	2.33
House 29	5.04	2.88	1.20	0.48	9.00				12.00		18.00				3.90	26.40							78.90	6.58
House 30	3.60	2.16	1.20	0.48	9.00				12.00		18.00				3.90								50.34	4.20
House 31	7.20	3.60	2.40		18.00			0.60	24.00						3.90								59.70	4.98
House 32	2.88	1.44	1.20	0.48																			6.00	0.50
House 33	4.32	1.44	1.20	0.48																			7.44	0.62
House 34	3.60	1.44	1.20	0.48					12.00														18.72	1.56
House 35	3.60	2.16	1.20		9.00				12.00														27.96	2.33
House 36	2.16	1.44	1.20		9.00			0.60															14.40	1.20
House 37	4.32	2.16	1.20	0.48	9.00				12.00						3.90								33.06	2.76
House 38	4.32	2.16	1.20	0.48				0.60	12.00											1.80			22.56	1.88
House 39	7.20	2.16	3.60	0.48	9.00				12.00							26.40		9.60					70.44	5.87
House 40	8.64	5.76	2.40	0.96	18.00			0.60	24.00		18.00				3.90								82.26	6.86
House 41	4.32	2.88	1.20	0.48	9.00			0.60	12.00		18.00				3.90								52.38	4.37
House 42	4.32	2.16	1.20	0.48	9.00																		17.16	1.43
House 43	2.88	1.44	1.20		9.00			0.60															15.12	1.26
House 44	4.32	2.16	1.20	0.48	9.00			0.60															17.76	1.48
House 45	4.32	2.16	1.20	0.48	9.00																		17.16	1.43
House 46	4.32	2.88	1.20												3.90			9.60					21.90	1.83
House 47	4.32	2.16	1.20	0.48	9.00																		17.16	1.43
Shop 1	0.72											1.20											1.92	0.16
Shop 2	1.44	0.72						0.12											4.80				7.08	0.59
Shop 3	0.72	0.72				9.00		0.12															10.56	0.88
Shop 4	1.44	0.72				9.00		0.12															11.28	0.94
Shop 5																							0.00	0.00
Shop 6																							0.00	0.00
Shop 7	2.16	1.44					24.00																27.60	2.30
Shop 8	2.88	1.44	2.40																		0.72		7.44	0.62
Shop 9	4.32	4.32	4.80			9.00		0.30															22.74	1.90
Shop 10	1.44	0.72																	4.80				6.96	0.58
Shop 11	1.44	0.72	1.20					0.12															3.48	0.29
Shop 12	1.44	0.72																					2.16	0.18
Shop 13	4.32	0.72	1.20					0.12											4.80				11.16	0.93
Shop 14	1.44	0.72						0.12				2.40											4.68	0.39
Shop 15	1.44	0.72					24.00	0.12															26.28	2.19
Shop 16	1.44	0.72	1.20					0.12											4.80				8.28	0.69
Shop 17	2.16	0.72						0.12														1.20	4.20	0.35
Shop 18	1.44	0.72	1.20																			1.20	4.56	0.38
Shop 19	1.44	0.72										2.40											4.56	0.38
Shop 20	1.44																						1.44	0.12
Shop 21	1.44	0.72			9.00			0.12															11.28	0.94
Shop 22	1.44	0.72						0.12															2.28	0.19
Shop 23	1.44	0.72					24.00	0.12															26.28	2.19
Shop 24	1.44	0.72			9.00																		11.16	0.93
Shop 25	1.44											1.20											2.64	0.22
Shop 26	2.16	0.72			9.00																		11.88	0.99
School	2.16	2.16						0.60												1.80			6.72	0.56
Office 1	3.60	2.16	1.20					0.60			36.00						9.60			5.40			58.56	4.88
Office 2	3.60	1.44						0.60									9.60			1.80			17.04	1.42
Church 1	5.76	4.32											4.80	4.80									19.68	1.64
Church 2	10.80	7.20	1.20										24.00				4.80			3.60			51.60	4.30
Mosque 1	7.20	2.88											4.80										14.88	1.24
Mosque 2	7.20	3.60											12.00										22.80	1.90
Total	**288.72**	**164.88**	**99.60**	**23.04**	**243.00**	**27.00**	**72.00**	**14.04**	**240.00**	**54.00**	**162.00**	**7.20**	**45.60**	**4.80**	**27.30**	**52.80**	**24.00**	**19.20**	**19.20**	**18.00**	**1.92**	**44.40**	**1652.70**	**137.73**

for production. With the addition of reliable electrical power supply the town can experience better growth socio-economically and industrially.

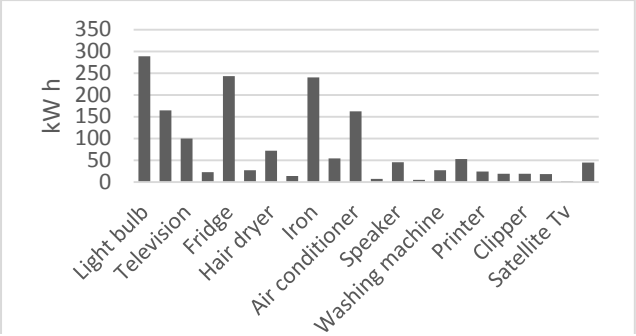

Fig 2: Bar Chart of Energy Consumption of Different Electrical Appliances

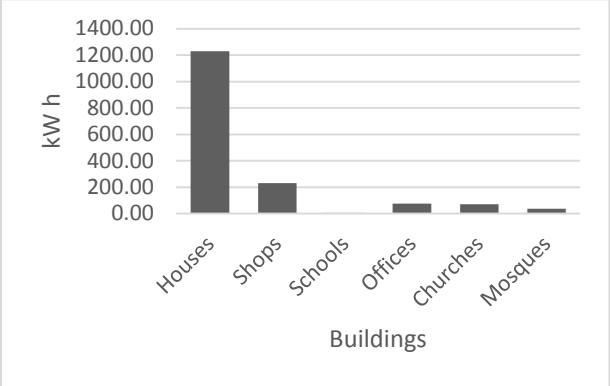

Figure 3: Energy consumption of Different Types of Buildings

4 Conclusion

The present energy demand of Asejire community alone is low, but the industry in the town consumes about eight times the energy demand of the community. Considering future expansion, the number of industries would increase and therefore, this would drastically increase the energy demand of Asejire town with the industries having more than 90 percent of the energy demand of the Asejire town.

Acknowledgement

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Appendix

QUESTIONNAIRE
DEPEARTMENT OF MECHANICAL ENGINEERING
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ENERGY AUDIT OF ASEJIRE COMMUNITY FOR A SMALL HYDROPOWER SCHEME

Dear Respondents,

This questionnaire is designed purposely to collect information on the above stated topic for research purposes. Any information provided will be used for the research purpose only and such information will be treated with high confidentiality.

Kindly please respond to the questions appropriately. Thanks in anticipation for your unreserved cooperation.

SECTION A

This section contains personal bio-data, and household information.

Name of respondent (optional): ……
Gender: ……..
Location of household: ……
Household type of ownership: ……..
Type of dwelling: ……
Number of rooms: ……
Number of occupants: ……..
Electric connection: Yes ☐ No ☐
Type of electric connection:
National grid ☐ Off-grid ☐
Duration of electricity: ……..
Type of electric power generation (off-grid): ……..

SECTION B

This section is to determine the electric appliances used by the respondent to aid the calculation of each household electrical consumption.

S/N	Appliances	Power Rating (kW)	Quantity	Operation Time (hr)	Energy Consumption (Kw h)
1					
2					
3					
4					